The Moment of Inertia Factor of Mars: Implications for Geochemical Models of the Martian Interior. C.M. Bertka and Y. Fei, Geophysical Laboratory and Center for High-Pressure Research, Carnegie Institution of Washington, 5251 Broad Branch Rd., N.W., Washington DC 20015 (e-mail: bertka@gl.ciw.edu)

Introduction: Data constraining the structure and composition of the Martian interior are limited. Presently, the strongest geophysical constraint we have for Mars is knowledge of the mass and radius of the planet. Using the mass and radius of the planet and the moment of inertia factor as constraints, two of three variables, mantle density, core size, and core density, can be calculated as a function of one of the three variables. Unfortunately, the Martian moment of inertia factor is not well known either. Bills (*1*) has argued that the commonly accepted moment of inertia factor of 0.365 may be too high and that lower values are equally feasible. Most models for the composition of the Martian mantle and core are dependent on knowledge of the moment of inertia factor of Mars (*2,3,4*). A lower value for the moment of inertia factor would imply a lower abundance of iron in the Martian mantle, less sulfur in the Martian core, or a thicker crust.

Dreibus and Wänke (*5*) used a geochemical model, element correlations between measured ratios in the SNC meteorites and C1 chondritic abundance, to derive a Martian mantle and core composition model, DW, that is independent of assumptions about the moment of inertia factor. Bertka and Fei (*6*) experimentally determined the mineralogy of the DW Martian mantle composition along a model P-T profile of the Martian interior. Using the experimentally determined phase assemblages, and the equations of state of the minerals stable at high pressure and temperature, we have calculated a model density profile of the DW Martian interior. For a given core composition, we have calculated the moment of inertia factor and the size of the core that simultaneously satisfy both the DW mantle density profile and the mass of the planet.

Given a successful Mars pathfinder mission, we will soon have a tighter constraint on the moment of inertia factor for Mars (*7*). In order to evaluate the DW mantle composition model in light of this future information, we have determined the uncertainty in our calculations due to the uncertainty in the Martian temperature profile, crustal thickness, and the composition the Martian core.

Results: The Dreibus and Wänke model predicts a core composition of Fe with 14 wt% S. The moment of inertia factor that we calculate for a DW model mantle and core is 0.368. This calculation assumes a high-temperature P-T profile for the Martian interior and does not include a crust. Choosing a low-temperature profile for the interior results in an increase of the moment of inertia factor of 0.001. We have also considered a variation in core composition from pure Fe to FeS. This variation results in a corresponding variation in core size, core size increases with increasing S content, but changes the moment of inertia factor by only ± 0.001. Assuming a DW mantle density profile, the moment of inertia factor is most sensitive to the density and thickness of the crust. Figure 1 illustrates how the moment of inertia factor changes as a function of crustal thickness and density, and mantle Mg# (Mg# = atomic (Mg/(Mg + Fe)) * 100), assuming an Fe core with 14 wt% S.

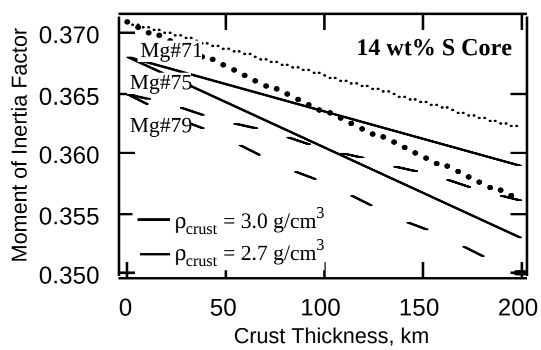

Figure 1. Moment of inertia factor as a function of crustal thickness and density, and mantle Mg#. Calculations assume an Fe core with 14 wt% S.

The DW mantle has an Mg# =75. Moment of inertia factors in the range of 0.365 to 0.357 are consistent with the DW model of mantle iron abundance if the crust of Mars is 42 km (2.7 g/cm^3) to 150 km (2.7 g/cm^3) thick. A lower moment of inertia factor, < 0.357, would require a lower mantle iron abundance than that predicted by the DW model or a crustal thickness >150 km. Given that 0.365

is the maximum value for the moment of inertia factor of Mars (*1*), a crustal thickness <42 km would also require a lower mantle iron abundance than that predicted by the DW model.

Discussion: The mean thickness of the Martian crust is not well constrained. Estimates range from 25 to 150 km (*8*). Given this uncertainty, a large uncertainty in mantle Mg# will exist despite a future improvement in our knowledge of the moment of inertia factor. For example, by varying crustal thickness and density within present estimates, a moment of inertia factor of 0.365 is consistent with a mantle Mg# of 77 to 64, 0.360 with Mg# 84 to 71 and 0.355 with Mg# 91 to 77. The Earth's upper mantle has an Mg# of 90. The Martian mantle may be more iron-rich than the Earth's mantle. Geochemical models like Dreibus and Wänke's, that calculate the iron content of the Martian mantle from the measured FeO/MnO ratio of the SNC meteorites, suggest that the Martian mantle contains 18 wt% FeO. The Earth's upper mantle FeO abundance is estimated to be 8 wt%. A determination of the amount of iron enrichment in the Martian mantle, if any, compared to the Earth's mantle, depends not only on an accurate determination of the moment of inertia factor of Mars, but also on knowledge of either Martian crustal density and thickness or Martian core size.

References:[1] Bills B.G. (1989) *Geophys. Res. Lett.* **16**, 385. [2] Morgan J.W. and Anders E. (1979) *Geochim. Cosmochim. Acta* **43**, 1601. [3] McGetchin T.R. and Smyth J.R. (1978) *Icarus* **34**, 512. [4] Goettel K.A. (1983) *Carnegie Inst. Washington Yearb.* **82**, 363. [5] Dreibus G. and Wanke H. (1985) *Meteoritics* **20**, 367. [6] Bertka C.M. and Fei Y. (1997) *J. Geophys. Res.* in press. [7] Bills B.G. (1996) *Lunar Planet. Sci. Conf.* **27**, 115. [8] Breuer D., Spohn T. and Wullner U. (1993) *Planet. Space Sci.* **41**, 269.